knees. Knees with RKOA had increased vertical-medial FDs compared to knees without OA (OR 1.8 per 1 SD increase in the average value of the FS, $p < 0.01$; OR 0.8 per 1 SD increase in the curvature of the FS, $p = 0.01$) (Figure 1). No association was seen between FS and incident RKOA. Figure 2 shows the lack of significant difference in the vertical-medial FS between case and control knees. Results were also not signficant for horizontal-medial and vertical- and horizontal-lateral FSs with incident RKOA.

Conclusions: In a cross-sectional analysis, vertical-medial FDs were increased in OA knees. This is consistent with previous studies and validates our measurement technique of FSA. The lack of association between FDs and incident RKOA suggests that any FS changes detected by our method prior to development of RKOA may be subtle (or insignificant) compared to the larger changes associated with prevalent RKOA. Studying relationships between alterations in bone texture and RKOA development and progression using alternative FSA and bone texture measurement techniques is warranted.

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COMPARISON OF STRUCTURAL FEATURES BY MRI AND RADIOGRAPHS IN PATIENTS WITH HAND OSTEOARTHRITIS

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Purpose: To examine whether MRI is more sensitive than conventional radiography (CR) in detection of structural hand osteoarthritis (OA) features.

Methods: We included 106 patients from the Oslo hand OA cohort (97 women, mean (standard deviation) age 68.9 (5.6) years) with MRI (coronal/sagittal/axial T1w fat-suppressed images) and posteroanterior CR of the dominant hand. One investigator (IKH) scored the distal interphalangeal (DIP) and proximal interphalangeal (PIP) joints for structural features according to the preliminary Oslo hand OA score for MRI (1); Osteophytes (grade 0–3; distal/proximal part of the joint), joint space narrowing (JSN) (grade 0–3), cysts (grade 0–1; distal/proximal), malalignment (grade 0–1; frontal/sagittal plane). Erosions (grade 0–3; distal/proximal) and subchondral collapse of the joint plate (grade 0–1; distal/proximal) were scored separately, in contrast to the proposed combined definition and grading. For joints that were scored for MRI pathology in both the proximal and distal part of the joint, we used the highest score for that joint. Intra-reader reliability was good to very good. One investigator (IKH) scored the same DIP/PIP joints according to the radiographic OARSI atlas; Osteophytes (grade 0–3), JSN (grade 0–3), subchondral erosions (grade 0–1), cysts (grade 0–1), and malalignment (grade 0–1). Intra-reader (IKH) and inter-reader (IKH, JB) reliability were very good for most features. We compared the number of affected joints (≥grade 1 pathology) by CR and MRI with Wilcoxon signed-rank test, and examined the agreement at individual joint level. Osteophytes and JSN were assessed on 0–3 scales by both modalities, and we calculated the percentage of exact agreement (PEA) and percentage close agreement (PCA; difference of ≤1 between modalities). In order to compare MRI-defined erosions against radiographic erosions, which were scored as absent/present, we dichotomised the MRI-defined erosion scores (grade 0=absent, grade 1–3=present). We calculated the PEA between radiographic erosions and MRI-defined erosions and between radiographic erosions and MRI-defined subchondral collapse. Cysts and malalignment were scored as absent/present by both modalities, and we calculated the PEA. Agreement between the two modalities was further assessed by calculation of kappa and sensitivity/specificity of MRI with CR used as reference.

Results: MRI detected more DIP/PIP joints with erosions ($p < 0.001$) and osteophytes ($p < 0.001$) than CR, while CR detected more joints with JSN ($p < 0.001$) and malalignment ($p < 0.001$). The difference was non-significant for cysts ($p = 0.66$). The sensitivity of MRI (with CR as reference) was very high for osteophytes and erosions, while the specificity was lower. The agreement between MRI-defined subchondral collapse and radiographic erosions was good. Cysts and malalignment were infrequent features with low to moderate agreement between the modalities (table).

Conclusions: MRI was more sensitive than CR in detection of osteophytes and erosions, which is probably due to the multiplanar demonstration of the joint by MRI. Malpositioned/flexed normal joints may appear narrowed on CR, and this may have contributed to decreased sensitivity of JSN for MRI compared with CR.

Table: Agreement between MRI and conventional radiography (CR)

	Percentage exact agreement	Percentage close agreement	Kappa	Sensitivity (CR reference)	Specificity (CR reference)
Osteophytes	36.8	93.7	0.41[a]	1.00	0.22
Joint space narrowing	55.3	98.1	0.50[a]	0.78	0.72
Erosions (MRI-defined erosions vs. radiographic erosions)	67.3	Not applicable (binary variables)	0.34	0.92	0.61
Subchondral collapse (MRI-defined subchondral collapse vs. radiographic eroions)	91.8	Not applicable (binary variables)	0.75	0.83	0.94
Cysts	92.0	Not applicable (binary variables)	0.11	0.16	0.96
Malalignment	91.7	Not applicable (binary variables)	0.50	0.43	0.98

[a]Weighted kappa.

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ARE SHORT-TERM RATES OF MRI-BASED MEASURES OF KNEE CARTILAGE LOSS MARKERS OF LONG-TERM CHANGE? FOUR-YEAR DATA FROM THE OA INITIATIVE

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Purpose: Most magnetic resonance imaging (MRI) studies on structural progression of knee osteoarthritis (OA) have relied on relatively short observation periods (e.g. 1 year). Although the rate of change is expected to increase linearly with the length of the observation period, it is currently unclear to what extent the sensitivity to change increases, and whether short-term cartilage loss predicts cartilage loss over longer observation periods in individual knees. Objectives of this study therefore were to determine 1) the mean change and the sensitivity to change of cartilage thickness (ThCtAB) loss over one-, two-, three-, and four years; 2) the consistency of the subregion with the greatest rate of change in each knee over different follow-up periods; 3) the relationship between short- and long-term changes and specifically whether short-term changes predict loss over longer periods.

Methods: Clinical and 3T sagittal DESS MRI data of 441 Osteoarthritis Initiative (OAI) participants (one knee each, 216 Kellgren & Lawrence grades (KLG) 2; 225 KLG3) were analyzed. Images were grouped by knee, but blinded to acquisition order for manual segmentation of femorotibial cartilage at baseline (BL), year one (Y1), year two (Y2), and year four (Y4). Mean change (MC) in ThCtAB and the standardized response mean (SRM=MC/SD of change) were computed over 1-year (BL → Y1, Y1 → Y2), 2-year (BL → Y2, Y2 → Y4), 3-year (Y1 → Y4) and 4-year time periods (BL → Y4). The ordered values (OV) approach was applied to determine the subregion showing the highest rate of change (OV1). Because precision errors occurring at common time points distort the association among the observed correlations (in positive [first/last observation] or negative direction [intermediate time point]), the short- and long-term changes without common time points (Y1 → Y2 vs. BL → Y4 / BL → Y1 vs. Y2 → Y4) were compared using Spearman rank correlation coefficients as well as the smallest detectable change (SDC) approach, classifying knees as (non-) progressors. The receiver operating characteristics (ROC) curve was determined using a fixed long-term (226 μm) and a variable short-term threshold and the area under the ROC curve was calculated to assess the predictive value of short-term loss for long-term changes.

Results: In the total femorotibial joint (FTJ), the MC% was −1.2%/−0.8% over one (BL → Y1/ Y1 → Y2), −2.1%/−2.2% over two (BL → Y2/ Y2 → Y4), −3.1% over three (Y1 → Y4), and −4.2% over four years (BL → Y4). The SRMs were −0.42/−0.28 over one, −0.56/−0.50 over two, −0.59 over three, and −0.74 over four years. The location of OV 1 was consistent between short- and long-term changes in 22%/14% of the knees (Y1 → Y2 vs BL → Y4 / BL → Y1 vs Y2 → Y4). The correlation between short- and long-term change was $r = 0.33$ (Y1 → Y2 vs. BL → Y4) and $r = 0.17$ (BL → Y1 vs. Y2 → Y4). Of 83 knees classified as progressors by SDC at Y1 → Y2, 60 (72%) also showed progression at BL → Y4. Fifty (46%) of the 109 knees progressing between BL → Y1 also progressed between Y2 → Y4. The area under the ROC curve was 0.64 for Y1 → Y2 vs. BL → Y4 and 0.61 for BL → Y1 vs. Y2 → Y4.

Conclusions: On a cohort-level, the rate of change in ThCtAB increased almost linearly with the length of the observation period, while the SRM increased from −0.42/−0.28 to −0.74 for a one- vs. four year observation period. When not including a common time points in the analysis, correlations of short- and long-term changes were weak to moderate. The application of the SDC approach showed a moderate consistency between the knees identified as progressors over short- and long-term periods. Longer observation periods may therefore be preferable to achieve robust results in individual knees.

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FEASIBILITY OF BONE DENSITY EVALUATION USING PLAIN DIGITAL RADIOGRAPHY

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Purpose: For the evaluation of subchondral bone density (BD) changes due to OA, Dual Energy X-ray Absorptiometry (DEXA) is the most validated method. The need for DEXA might be reduced if the quantitative measurement of clinically relevant BD changes on radiographs is proved feasible, since radiographs are commonly acquired to evaluate structural changes due to OA. Precision of BD evaluation might be influenced by variations in acquisition settings that commonly occur in clinical practice and by post-processing (PP) that was introduced with the transition from conventional film-screen radiography to digital radiography. The objective of this study was to evaluate the effects of PP and acquisition settings on the precision and with that feasibility of BD measurement using plain digital radiography.

Methods: A bone density standard (BDS) was created consisting of eight cups with hydroxyapatite (HA: range 1.0–5.75 g/cm^2). Digital radiographs of the BDS were taken (Philips Digital Diagnost), with variations in the acquisition and PP settings. Tube voltage (in kilovolt: kV), exposure (in milliampere seconds: mAs), tube added filtering, and BDS position in the field-of-view were systematically varied and the default clinical PP was compared with minimal PP (at minimal strength). An aluminum step wedge served as an internal reference to express gray values of the BDS in mm aluminum equivalents (mmAl), by use of custom made software. In all cases a human (cadaver) knee joint was added to simulate clinical conditions. The relation (R^2) between the BD values normalized to the reference wedge (in mmAl equivalents) and actual BD (HA in g/cm^2), with variations in acquisition and PP settings was evaluated with linear regression analyses. Precision of BD measurement of the BDS was calculated in early OA (Cohort Hip & Cohort Knee: CHECK) to evaluate the relevance for clinical (research) practice.

Results: The BDS was validated by DEXA scanning and the relation between actual HA (g/cm^2) and DEXA values was strongly linear: R^2=0.99. In general for digital radiographs a strong correlation between actual BD and BD in mmAl was found for all settings. The correlation improved by changing PP from clinical (R^2=0.96) to minimal (R^2=0.98). Higher kV improved the correlation further. Even, for clinical PP mean SD was 0.97 mmAl, much smaller than the change of 2.51 mmAl clinically observed during two-year follow-up in early OA which implies the feasibility of BD measurements using plain digital radiography.

Conclusions: Accurate bone density measurement using digital radiography is feasible in a clinically relevant range, which removes the need for additional DEXA scans since plain radiographs are acquired for to evaluate structural changes due to osteoarthritis. Care should be taken in changing post-processing and acquisition settings, which can have profound effect on outcome.

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THE OCCURRENCE OF CAM IMPINGEMENT IN YOUNG MALE SOCCER PLAYERS

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Purpose: Femoroacetabular Impingement (FAI) is a cause of hip pain and might cause osteoarthritis (OA) of the hip due to abnormal contact between the femoral neck and acetabulum. Cam impingement is a subtype of FAI, in which the abnormal contact is caused by a cam-type deformity in the femoral head-neck junction. Cam impingement is mostly seen in young active males. However, no studies have focused on the presence of cam-type deformities during skeletal development. This study aimed to determine the age of onset and prevalence of cam-type deformities in young male soccer players versus non-athletic controls.

Methods: 89 elite pre-professional soccer players and 90 controls aged 12–19 years were included in this study. In the soccer players group, both an anteroposterior (AP) and a Lauenstein radiograph of the hip were obtained according to a standardized protocol. Controls with both an AP and a Lauenstein radiograph with no signs of hip pathology were obtained from radiology databases. The alpha angle was calculated in all radiographs using semi-automatized software. An alpha angle larger than 60° was considered to define a cam-type deformity. All radiographs were scored by an orthopedic surgeon and a radiologist, using a three-point scoring system. The anterosuperior head-neck junction was classified as normal (1), flattened (2) or having a prominence (3). The soccer players completed a questionnaire, and range of motion (ROM) and impingement tests were performed. Differences in prevalence were tested using logistic regression, corrected for age. Differences between the mean alpha angle in soccer players and the control group, and differences in the ROM between cam-type deformity cases and normal soccer players were tested using Generalized Estimating Equations, corrected for age.

Results: The mean age was 14.8 years for the soccer players and 13.7 years for the controls. An alpha angle >60° was first found at the age of 12 in some soccer players and controls. A cam-type deformity defined by alpha angle was more prevalent in soccer players (26%) than in controls (18%), though not significantly when corrected for age (Figure 1).

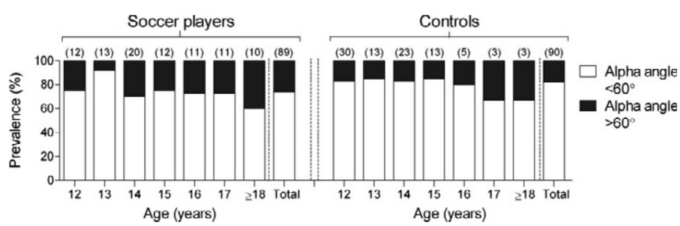

Fig. 1. The prevalence of a cam-type deformity (alpha angle >60°) per age in soccer players and controls. In both soccer players and controls an alpha angle >60° was found starting at the age of 12 years. Total number (n) per age is given on top of each bar.

The mean alpha angle in the soccer players was larger than in controls in both the Lauenstein view (50.8 vs 46.8, p = 0.002), and the AP view (50.9° vs 48.0° p = 0.079). A prominence in the anterosuperior head-neck junction was first found at the age of 13 years and the prevalence was 13.5% in the soccer players. No prominences were found in the controls. A flattening of the head-neck junction was also more frequently found in the soccer players (53% vs 19%, p = 0.0001) (Figure 2).

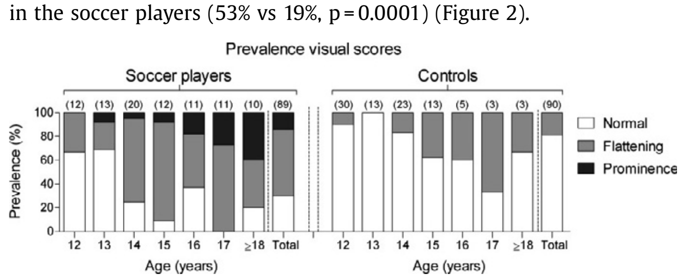

Fig. 2. Both a flattening and a prominence in the anterior head-neck junction were significantly more frequent in soccer players than in controls. Aspherical hips were especially found from the age of 14 years, starting with a flattening and with increasing age more prominences were found in the young soccer players.

Internal rotation was significantly reduced in soccer players with a cam-type deformity defined by alpha angle (19.7 vs 26.2, p = 0.002), whereas a positive impingement test did not associate with the presence of a cam-type deformity.

Conclusions: A cam-type deformity can be present and recognizable from the age of 13 years. Cam-type deformities are more prevalent, and more pronounced in young soccer players than in their non-athletic